(12) UK Patent Application (19) GB (11) 2 163 603 A

(43) Application published 26 Feb 1986

(21) Application No 8421626

(22) Date of filing 25 Aug 1984

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(51) INT CL[4]
H01F 27/28

(52) Domestic classification
H1T 14 1C 7A8 7C1A 7C1B1 7C3 7C5 7C6 8
U1S 2082 2087 H1T

(56) Documents cited
GB 1210364 GB 1116161 EP A1 0035964
GB 1180923 GB 0993265

(58) Field of search
H1T

(54) Miniature transformer or choke

(57) A small low profile lamina transformer in which photoetched lamina windings, 1,2 are each in two halves one half on each side of an insulating lamina, the halves being interconnected by a plated through hole, and the winding terminals being outside the area of the winding and adjacent each other.

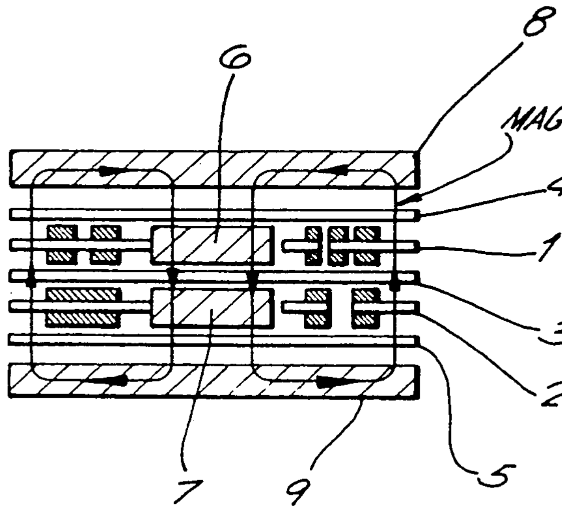

Fig. 1.

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The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

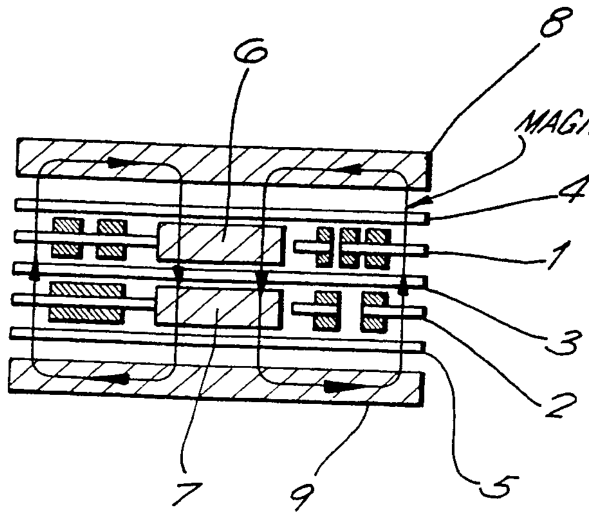
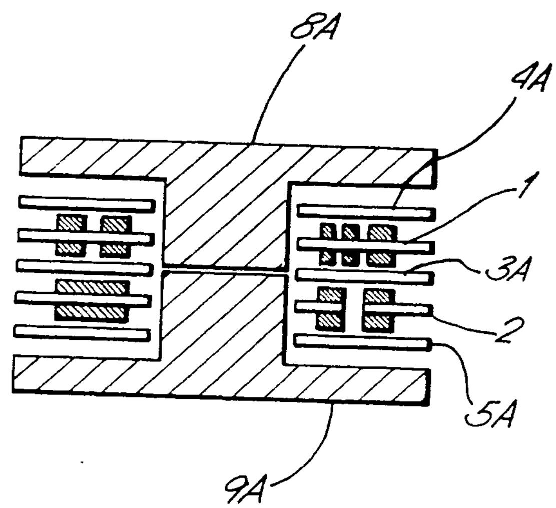


Fig. 1.

Fig. 5.



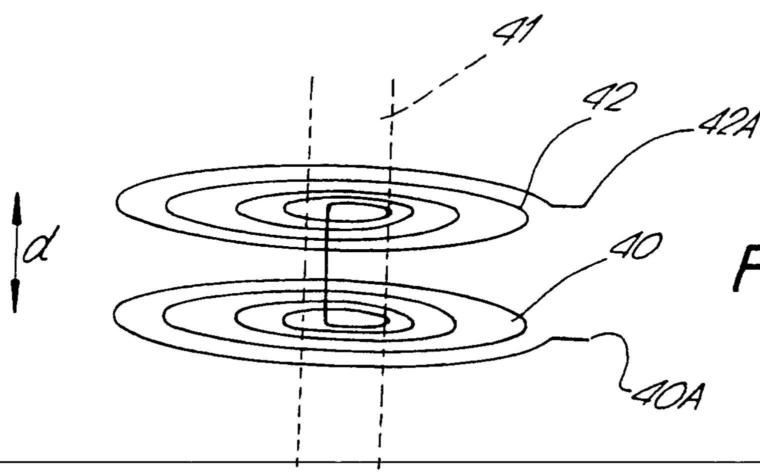


Fig. 6.

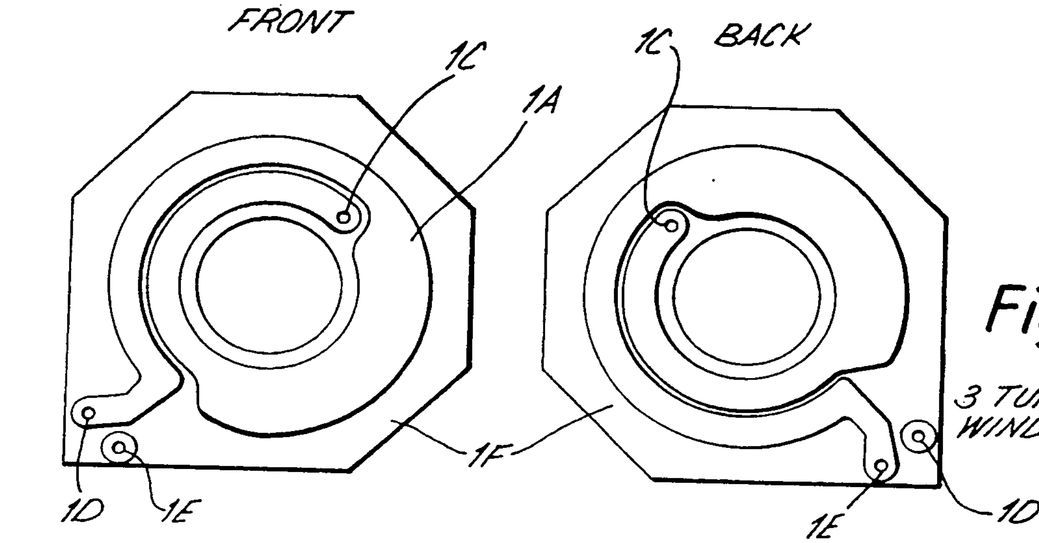


Fig. 2A.

3 TURN WINDING

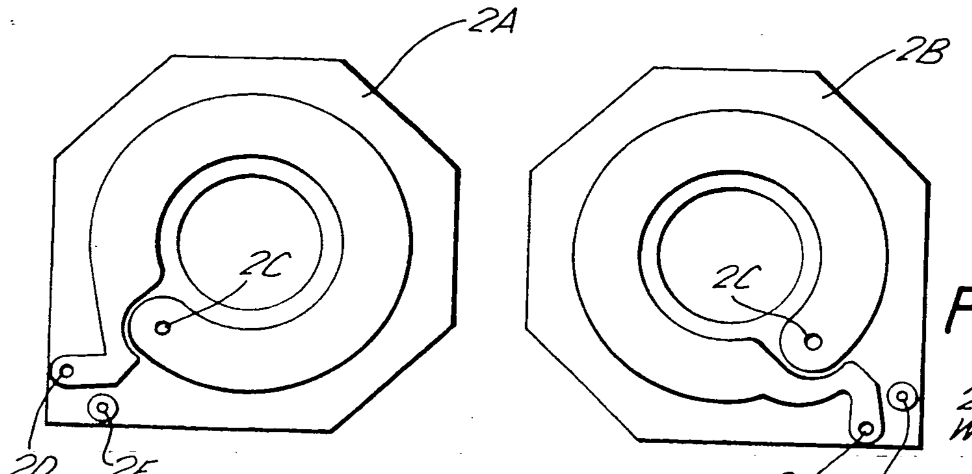


Fig. 2B.

2 TURN WINDING

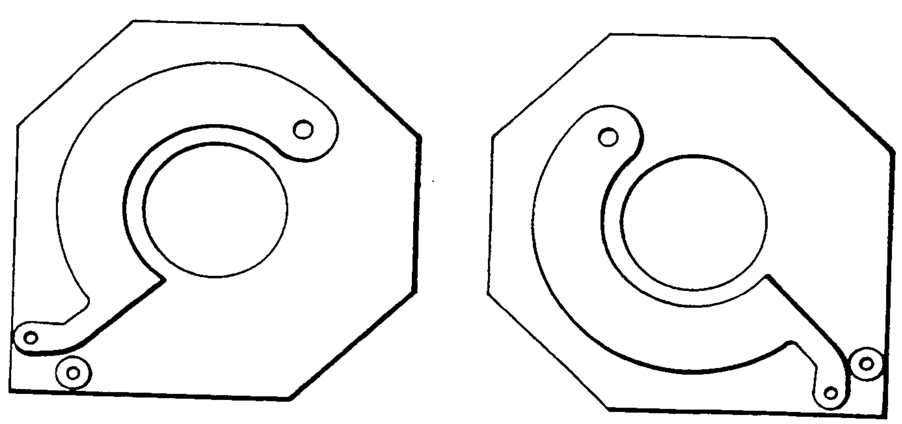


Fig. 2C.

1 TURN WINDING

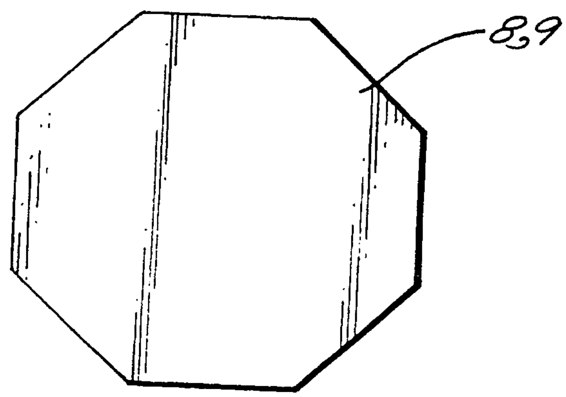


Fig . 3A.

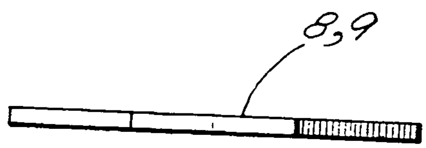


Fig . 3B.

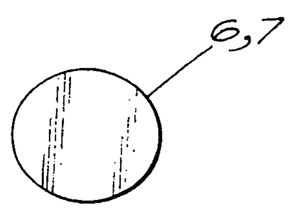


Fig . 3C.

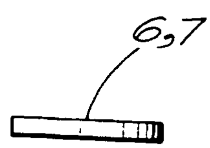


Fig . 3D.

Fig. 4A.

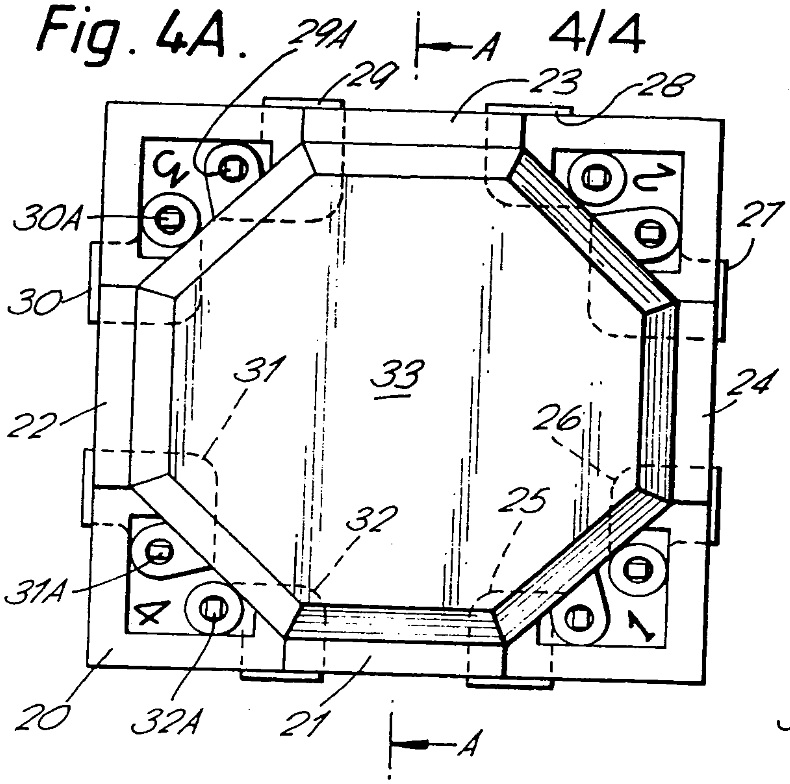


Fig. 4C.

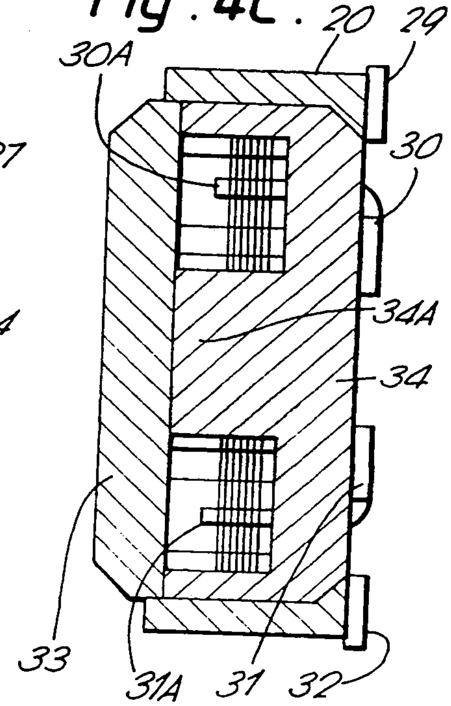


Fig. 4B.

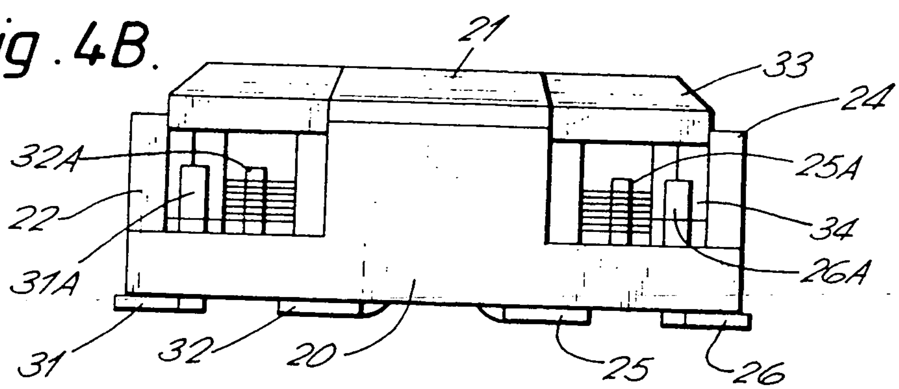
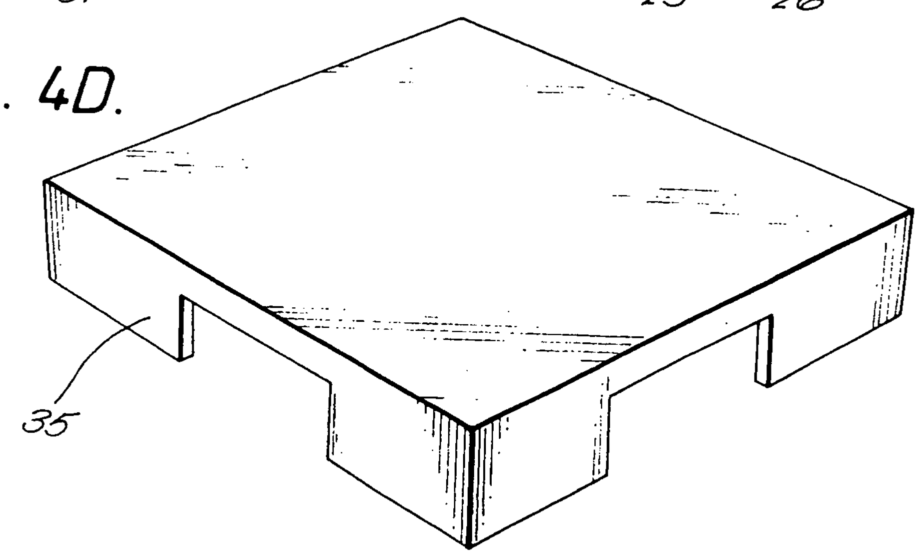


Fig. 4D.



SPECIFICATION

Miniature wound comp nent

This invention relates to a miniature wound component such as a transformer particularly for high frequency operation.

Miniature transformers are used in many circuit applications and one particular application is switched mode power supplies for e.g. DC to DC conversion. Here high frequency pulses are processed and the frequencies involved lie in the range 20KHz to 100KHz. Small switched mode power supplies are currently available on a single printed circuit board for mounting directly on a larger circuit board. Since most circuit components, particularly integrated circuits, have a low profile, the power supply tends to be higher than the other components and thus causes wasted space between adjacent printed circuit boards.

One of the limiting factors in reducing the height of a printed circuit board switched mode power supply is the height of the miniature transformers used.

Current miniature transformers comprised a conventional plastics moulded bobbin carrying the external connection terminals and mounted in a two-part ferrite core which itself is held together by an external casing. The overall height of the transformer is dictated mainly by the wound plastics moulded bobbin. It is also found with conventional miniature transformers that the various electrical parameters, including parameters such as leakage inductance leakage capacitance etc, vary within fairly wide tolerances and although some of these parameters are not detrimental to the performance of the transformer, their wide variation can make the operation of the overal circuit in which the transformer is used, difficult to control so that the yield of circuits performing to a tight electrical specification, is necessarily reduced.

It is an object of the present invention to provide a miniature wound component with a lower profile than existing components, and in which the electrical tolerances can be much tighter. In particular it is envisaged to produce a wound component for operation at frequencies in the range 200KHz to 500KHz.

According to the present invention there is provided a miniature wound component comprising at least one winding formed by a first lamina coil portion on one side of an insulating sheet and a second lamina portion on the opposite side of the sheet, the portions being interconnected through the sheet within the areas of the portions, and connection terminals of the winding being outside the areas of the windings.

Preferably the connection terminals are located adjacent one another so as to minimise the inductance of the connection terminals.

Conveniently the two winding portions can be interconnected through the sheet by using plated through holes.

In order that the invention can be clearly understood reference will now be made to the accompanying drawings in which:–

Figure 1 shows schematically a lamina transformer with two lamina windings, according to an embodiment of the present invention;

Figure 2 shows the winding portion details of Fig. 1;

Figure 3 shows a plan and edge view of the soft magnetic laminae of the transformer of Fig. 1;

Figure 4 shows a plan and side view, a cross section and the cover of a four winding transformer assembly according to an embodiment of the invention; and

Figure 5 shows an alternative form of the lamina transformer of Fig. 1 with shaped central magnetic cores.

Referring to Fig. 1 two lamina windings 1 and 2 are placed together with an insulating lamina 3, of e.g. polyimide, between them and two similar insulating laminae 4 and 5 on the outside of the winding assembly. Within the winding assembly are placed two disc-like soft magnetic laminae 6 and 7. Further to the outside of this winding assembly are placed two soft magnetic laminae 8 and 9, of a high frequency ferrite.

Referring to Fig. 2 the lamina winding 1 of Fig. 1 is shown in Fig. 2A and the lamina winding 2 of Fig. 1 is shown in Fig. 2B. The lamina winding of Fig. 2A is a three-turn winding, the front producing a winding portion of one and a half turns and the back producing a second winding portion of one and a half turns. Within the areas of the windings the winding portions 1A and 1B are interconnected at 1C with a plated through hole and the external connection terminals 1D and 1E are also arranged with plated through holes.

The lamina windings are photoetched from double sided flexible printed circuit laminate. This typically has a thin copper carried on either side of a thin polyimide lamina 1F. The winding has half of the number of turns on one side of the lamina and the remaining half of the turns on the other side. The two halves 1A and 1B are joined by the plated through holes 1C at the interconnection point and 1D and 1E at the external connection terminals.

As can be seen the turns of the winding start from the outside of the winding, i.e. outside the areas of the windings at the external connection terminal 1D and move radially inwards in a spiral towards the plated through hole at 1C. On the other side of the lamina the turns move radially outwards in a spiral but maintain the same transverse direction around the centre of the winding.

The lamina windings are photoetched and are therefore consistent in size, shape and position. As shown in Fig. 2, their fronts and backs are identical and this means that they

can be assembled in the lamina transformer either way up.

As the external connection terminals to the winding are close together, connections to these tags may be kept side by side to maintain the inductance of these connections and through the connection terminals, to a minimum.

Figs. 3A and 3D show the actual shape of the soft magnetic laminae 8 and 9 and 6 and 7.

Fig. 2B shows the winding 2 of Fig. 1 which is a two-turn winding, one winding portion 2A providing one complete turn and the second winding portion 2B on the opposite side providing the second winding portion. Once again the winding portions are connected together by plated through holes at the interconnection point 2C and at the external connection terminals 2D and 2E.

Had a single turn winding been required then this alternative is shown in Fig. 2C.

It will be noted that as the lead in and lead out of a lamina winding, i.e. the connection terminals such as 1D and 1E, where they are covered by the soft magnetic laminae, which carry the magnetic flux, coincide on the two sides of the lamina, leakage inducatance of the transformer is minimised.

Although as mentioned above a double sided polyimide lamina carrying the two copper tracks can be used so that there is a single insulating lamina with the tracks fixed on both sides, there is at present little advantage in making the two winding portions on the one carrying lamina because such lamina is no thinner than the insulating laminae 3, 4 and 5. Good close coupling between winding portions can be achieved if the insulating laminae are thin, and there is an advantage in making each winding portion on its own separate lamina, as shown in Fig. 2, because different lamina portions can be combined to provide a number of different lamina transformers with different turns ratios from only a small set of piece parts.

The separation between the spiral tracks in each winding portion is small and is determined by the ease by which photoetching can be achieved. It is usually about twice the thickness of the copper track. The remainder of the copper in the tracks conducts the electrical current and if the separation between the tracks is disregarded, for similar thicknesses of copper, the ampere-turns rating of each lamina winding is the same. This is because each winding should cover the same area of the lamina, in order to have close consistent coupling between the windings. Keeping the shapes of the lamina windings the same, the ampere turns rating may be increased by increasing the thickness of the copper from which the tracks are photoetched.

Alternatively the effective ampere turns ratings can be increased by having several lamina windings connected in parallel. When this is done, coupling between windings may be further enhanced by interleaving parallel laminae of several windings.

If the soft magnetic laminae shown in Fig. 3 are of a common thickness, a number of these may be used to sandwich the winding assembly, sufficient to carry the required magnetic flux. In this way once again a small set of piece parts can provide a number of different lamina transformer constructions.

Referring back to Fig. 1 the insulating laminae 3, 4 and 5 do not have holes in their centres to accommodate the central disk-like magnetic laminae 6 and 7: in this way good creepage distances are maintained between the windings and the soft magnetic laminae. If this is of less consequence, then by having holes in the insulating laminae and having shaped ferrite soft magnetic laminae with low central cores, then the magnetic permeance can be increased, and an example is shown in Fig. 5. It is possible, further, that such magnetic cores can incorporate peripheral return paths.

Referring now to Fig. 4 there is shown schematically a lamina transformer assembly having four windings. The transformer comprises a flat plastic former 20 of square configuration with four upstanding wall portions 21, 22, 23 and 24. Into the former are loaded the piece parts making up the transformer. These piece parts comprise a sandwich structure of four lamina windings each as shown in either of Figs. 2A, 2B or 2C together with interleaved insulating laminae such as 3, 4 and 5. A two-part ferrite core 33 and 34 containing the sandwich structure part 34 has a central core 34A and four upstanding legs such as 34B leaving openings 34C at the corners of the plastics former 20 for the external connection terminals of the lamina windings.

The plastic former 20 has rectangular turned-over connected tags 25 to 32 as shown in dotted line in Fig. 4A. These tags which just project beyond the sides of the former are connected to the respective lamina windings by tag projections such as 25A and 26A being soldered to the pertaining connection terminals such as 1D and 1E of winding 1 in the bottom right hand corner of Fig. 4A. Similar tag projections 31A and 32A are soldered to winding terminals 2D and 2E of winding 2.

In the transformer described when the sandwich laminae are assembled in the part 34, the "lid" 33 is put on and the assembly put in the former 20 and the electrical connections made.

Once assembled, to cover 35 is put on and the parts of the lamina transformer may be held in the plastic former by a final piece of adhesive tape (not shown) around the assembly.

Alternatively cooperating pips and depressions on the interfitting parts of 20 and 35 can be used to hold these parts together without the need for the tape.

Clearly a choke can be made using the techniques described above, if just one lamina winding is used, which could of course include a number of lamina windings connected in parallel, used to create a choke.

In the earlier embodiments described the central soft magnetic disc-like lamina 6, 7 increase the magnetic permeance of the transformer; however this central region of the winding assembly is thin and of relatively large cross-sectional area, so that these two central laminae may be left out without greatly reducing the magnetic permeance. The return path for the magnetic flux, indicated by dashed line in Fig. 1, is at the periphery of the laminae, where the relatively large cross-sectional area keeps the permeance reasonably high, even through the winding assembly.

The lamina transformers described are small and in particular flat and are designed for use with high frequency electric currents, e.g. 200KHz to 500KHz such as in a hybrid regulator for a switched mode power supply. It is thus suitable for applications where low profile is required such as in hybridf circuits using surface mounted components.

The transformer of Fig. 4 has an overall height of 7.5mm.

Instead of photetched laminate, it would be possible to make a lamina winding of double insulated wire which is wound like double catherine wheel then heated to cause the outer plastics insulation to fuse to form an integral self-supporting lamina winding. This is shown diagrammatically in Fig. 6 where a first winding portion 40 is wound on a mandrel 41 (shown in broken line for clarity) and then a second winding portion 42 is wound in the same direction from another length of the same wire. The distance d between the windings is greatly exaggerated for clarity and in practice would be reduced to just the thickness of the primary enamel insulation on each winding portion when the two portions are axially compressed and heated to fuse the outer insulation layer to provide a self-supporting lamina winding. Such winding, can be assembled and connected by the end connections 40A, 42A in the same way as the photoetched windings in the final wound component, in particular the transformer described earlier.

CLAIMS

1. A miniature wound component comprising at least one winding formed by a first lamina coil portion on one side of an insulating sheet and a second lamina portion on the opposite side of the sheet, the portions being interconnected through the sheet within the areas of the portions, and connection terminals of the winding being outside the areas of the windings.

2. A component as claimed in claim 1 wherein the connection terminals are adjacent to one another.

3. A component as claimed in claim 1 or claim 2, wherein the interconnection between the winding portions is effected with a plated through hole.

4. A component as claimed in any preceding claim, wherein the winding portions are formed by etched conductive layers on a double sided flexible printed circuit laminate.

5. A component according to any preceding claim, wherein the winding portions of a winding are substantially identical.

6. A component according to any preceding claim, and of substantially rectangular configuration the connection terminals for the or each winding lying at a respective corner of the rectangle.

7. A component according to any preceding claim, comprising an insulating plastics support frame carrying connection tags for connecting the transformer to external circuitry, the frame having side walls between which are located the lamina windings and soft magnetic circuit.

8. A choke or transformer substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

Printed in the United Kingdom for
Her Majesty's Stationery Office, Dd 8818935, 1986, 4235.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.